COMMISSIONS 27 AND 42 OF THE IAU
INFORMATION BULLETIN ON VARIABLE STARS

Number 5762

Konkoly Observatory
Budapest
2 April 2007

HU ISSN 0374 – 0676

RAPID CHANGES IN THE LIGHT CURVE OF THE ACTIVE, LATE-TYPE SUBGIANT CF OCTANTIS

INNIS, J.L.[1]; COATES, D.W.[2]; KAYE, T.G.[3]

[1] Brightwater Observatory, 280 Brightwater Rd., Howden, TAS, 7054, Australia, email: brightwater@iraf.net

[2] School of Physics, Building 27, Monash University, VIC, 3800, Australia

[3] Spectrashift, 404 Hillcrest, Prospect Heights, IL 60090, USA

CF Octantis (HD 196818) is a very active late-type (K0) subgiant showing strong Ca II emission (e.g. Hearnshaw, 1979; Innis et al., 1997) and a 20.15-d spot wave of varying amplitude (Innis et al., 1983; Lloyd Evans & Koen, 1987; Pollard et al., 1989; Innis et al., 1997). The radial velocity data of Lloyd Evans (1986), Balona (1987), Collier Cameron (1987a) and Innis et al. (1997) show no evidence for binarity. The star is active at radio wavelengths (Slee et al., 1987a, 1987b; Vaughan & Large, 1987), indeed it appeared as one of the stronger flaring microwave sources seen in the Parkes survey. It also appears in the ROSAT bright source catalogue (Schwope et al., 2000).

Apart from the work mentioned above, CF Oct has not been well studied, probably in part due to its high southern declination. It was first noted as a variable star on the Bamberg Southern Sky Survey photographic plates (Strohmeier, 1967). A recent reanalysis of the Bamberg material recovered the spot-wave light curve for the years 1964–1969, with some data from 1970, 1971, and 1976, showing the overall light variation of the star from that time (Innis et al., 2004). This photographic material, and the photoelectric photometry noted above, showed that while the spot wave was variable, the changes were slow, and often data from many rotations, or even at times from different seasons, could be combined to produce reasonably well defined light curves. In contrast, our recent data, presented here, reveal the star underwent a rapid change in the form of its spot wave in a very short interval, possibly also showing a low level of continuous change.

We commenced observations of CF Oct in mid 2006. We used an ST7 CCD and motorised BVR filter wheel on a 70-mm diameter, 480-mm focal length refractor. The field of view of the CCD was 0.8×0.55 degrees. (See Innis et al., 2007, for more details of the equipment and method.) CF Oct and the comparison star HD 196520 could be obtained on the same frame. HD 196520 was also used as a comparison star by Lloyd Evans et al. (1983), Collier Cameron (1987b), Pollard et al. (1989) and Innis et al. (1997), and has not been seen to vary. CF Oct and HD 196520 are almost identical in $B-V$, so that colour transformation corrections are negligible. We use $B-V = 1.07$ and $V = 7.60$ (Innis et al., 1997) for HD 196520.

CF Oct was observed for a total of 38 nights between 2006 July and 2007 March. We collected four 45-second B and four 30-second V exposures in succession and averaged the measurements, so that each resultant data point represents an equivalent 180- or 120-second integration in B and V respectively. We typically repeated this sequence at least four times on a given night. We have in total around 240 measurements (each composed of a 4-point average as noted) in each of B and V. The resulting V-light phase plot, using the period of 20.15 d (from Pollard et al., 1989; Innis et al., 1997) is shown in Figure 1. On any given night the scatter in the data is not much greater than the nominal ± 0.01 mag error bar shown in the top left of the Figure. We have inspected the magnitude differences between the comparison star HD 196520 and several fainter field stars, and find no evidence for long-term change greater than 0.01 or 0.02 mag. (We had originally intended using the star CPD -80 966 as the check star, but our data have shown this to be a red semiregular star, Innis et al., 2006.) We conclude that the scatter seen in the phase plot was due to real changes in CF Oct.

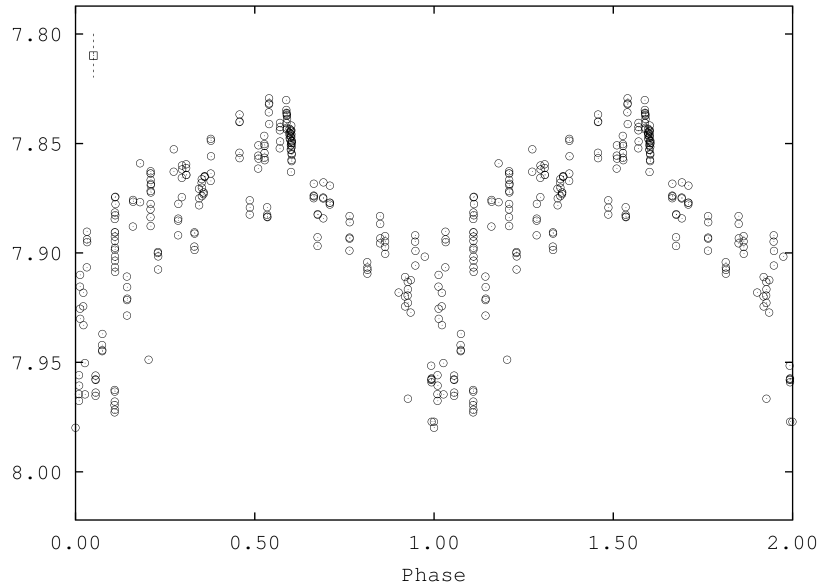

Figure 1. CF Octantis V light curve for 2006 July–2007 March, phased with the known 20.15 d rotation period. The symbol in the top left of the plot represent a typical error bar per point of ± 0.01 mag. The scattered nature of the plot is due to a real variation in the star

The changes in CF Oct are more easily seen in Figure 2, where we plot V magnitude versus HJD. We also show two least-squares fitted sine waves to better illustrate the changes. These are not intended to be fits to the data (the star clearly does not have a pure sinusoidal variation) but are to assist in judging the phasing of the data when inspecting the plot. We fixed the periods of the sine waves to be 20.15 d, and allowed the amplitudes, mean levels and phases to be determined in the fit. We arbitrarily split the data at HJD 2454040 when fitting the two sine waves.

The amplitude of the first segment of data (pre HJD 2454040) is about 0.12 mag peak-to-peak, which is around twice that of the later data. It appears that both maximum and minimum light have changed over the course of the observations, with maximum light being several hundredths of a magnitude fainter at the end of the data set compared to the start. The change in maximum light has the appearance of a step-like decrease near HJD 2454040. Minimum light appears to have brightened, but possibly in a more gradual manner, and may have been continually variable.

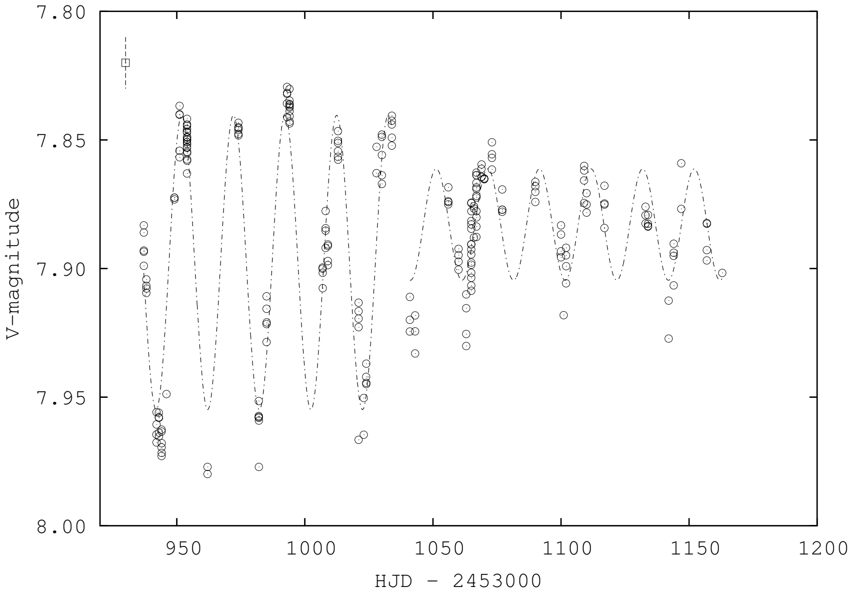

Figure 2. CF Octantis V light curve versus HJD for 2006 July–2007 March (circles). The lines represent two least-squares fitted sine curves, as a schematic representation of the data before and after HJD 2454040. It is clear that the light curve is variable, possibly continually variable, but that a significant change occurred near the above noted date. The symbol in the top left of the plot represent a typical error bar per point of ±0.01 mag

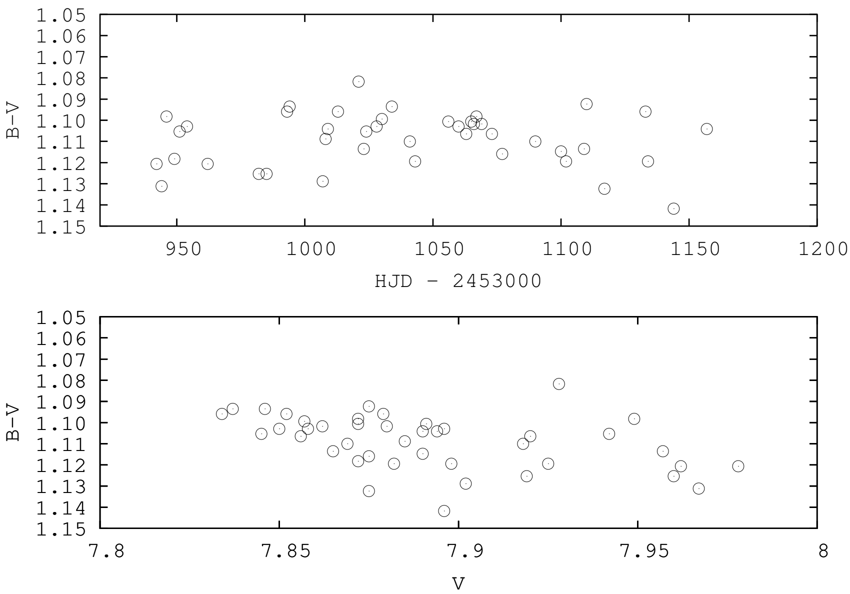

Figure 3. Top panel: CF Octantis $B-V$ light curve versus HJD. These are nightly averaged points. Lower panel: Nightly averaged $B-V$ versus V

Such rapid changes in the light curve of CF Oct have not been previously reported. Possibly the starspots are currently undergoing an interval of rapid change. It is also possible that the earlier published observations represented an unusually stable interval of spot behaviour, although the photoelectric data cover the interval ~ 1979 to ~ 1989.

Changes in the light curve of the fast-rotating, active star FK Com have been interpreted as being due to either *phase jumps*, when a new spot (or spot group) first appears around 90° in longitude away from an existing spot, or as *flip-flops* when a new spot first appears 180° away from a decaying spot (Oláh et al., 2006). The recent behaviour of CF Oct, with a contemporaneous variation in minimum and maximum light, may be suggestive of similar types of changes. Further analysis is planned.

Our nightly averaged $B-V$ data are shown in Figure 3. The top panel shows $B-V$ versus HJD, while the lower panel shows $B-V$ versus V. A clear gradient is seen in the lower panel, which is similar to the spot-induced colour change reported in Pollard et al. (1989) and Innis et al. (1997). These new data suggest CF Oct may be slightly bluer at a given V magnitude compared to the 1980s-era photoelectric photometry, but small errors in the transformations may equally well account for the differences.

We will continue to monitor this star. It would be of interest to obtain new spectroscopic observations of the Ca II and Hα lines, and also see if the possible increased activity is manifested in the radio and X-ray spectral regions.

Acknowledgments: We thank D. Partridge, S. Norris, and T. Moon for assistance with the construction of the observatory. We thank Doug George of Diffraction Limited for data-acquisition software support. This work has made use of the SIMBAD database of the Stellar Data Centre (CDS) Strasbourg, the NASA ADS abstract database, and the data-reduction packages IRAF (NOAA, USA) and MUNIWIN (by David Motl).

References:

Balona, L.A., 1987, *SAAO Circ.*, **11**, 1
Collier Cameron, A., 1987a, *SAAO Circ.*, **11**, 13
Collier Cameron, A. 1987b, *SAAO Circ.*, **11**, 57
Hearnshaw, J.B., 1979, *Proc. IAU Colloq.*, **46**, 371
Innis, J.L., Coates, D.W., Dieters, S.W.B., Moon, T.T., Thompson, K., 1983, *IBVS*, No. 2386
Innis, J.L., Coates, D.W., Thompson, K., 1997, *MNRAS*, **289**, 515
Innis, J.L., Borisova, A.P., Coates, D.W., Tsvetkov, M.K., 2004, *MNRAS*, **355**, 591
Innis, J.L., Coates, D.W., Kaye, T.G., 2006, *PZP*, **6**, 29
Innis, J.L., Coates, D.W., Kaye, T.G., 2007, *PZ*, **27**, 1
Lloyd Evans, T., Koen, M.C.J., Hultzer, A.A., 1983, *SAAO Circ.*, **7**, 82
Lloyd Evans, T., 1986, *SAAO Circ.*, **10**, 11
Lloyd Evans, T., Koen, M.C.J,, 1987, *SAAO Circ.*, **11**, 21
Oláh, K., Korhonen, H., Kővári, Zs., Forgács-Dajka, E., Strassmeier, K.G., 2006, *A&A*, **452**, 303
Pollard, K.R., Hearnshaw, J.B., Gilmore, A.C., Kilmartin, P.M., 1989, *J. Astrophys. Astron.*, **10**, 139
Schwope, A.D., et al., 2000, *AN*, **321**, 1
Slee, O.B., et al., 1987a, *PASAu*, **7**, 55
Slee, O.B., et al., 1987b, *MNRAS*, **229**, 659
Strohmeier, W., 1967, *IBVS*, No. 178
Vaughan, A.E., Large, M.I., 1987, *PASAu*, **7**, 42